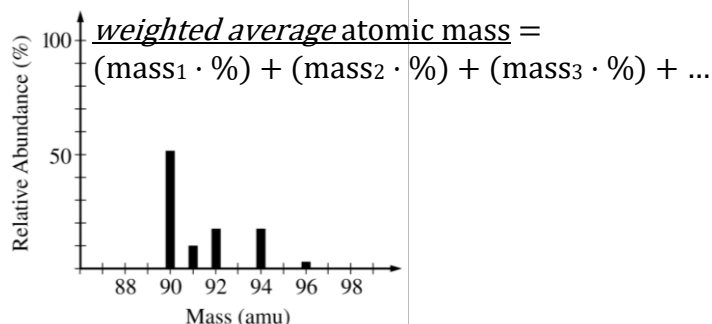


REVIEW SHEET including EQUATIONS and CONSTANTS

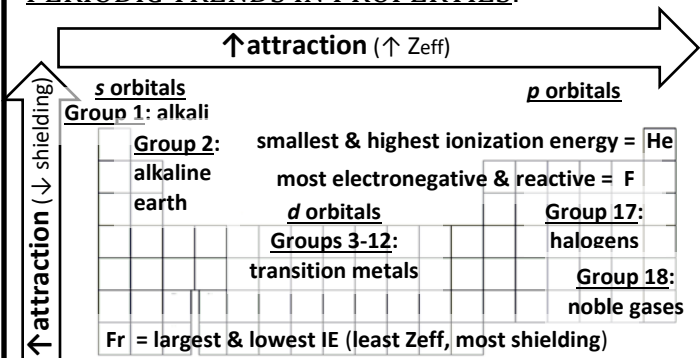
ATOMIC STRUCTURE

Unit 1

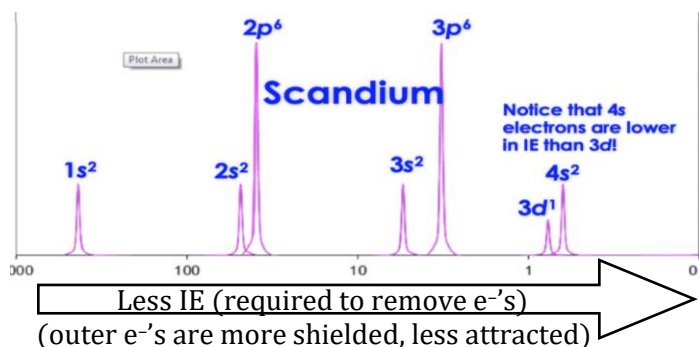
MASS SPECTROMETRY



PERIODIC TRENDS IN PROPERTIES:



PHOTOELECTRON SPECTROSCOPY (PES): (x-rays)



ENERGY (light and electrons)

$$E = h\nu \quad (\text{for 1 photon of light})$$

E = energy (J)

$h = 6.626 \times 10^{-34}$ (J·s)

ν = frequency (s^{-1})

1 kJ = 1000 J

$$c = \lambda\nu \quad (\text{for 1 photon of light})$$

$c = 2.998 \times 10^8$ (m/s) (speed of light)

λ = wavelength (m)

1 m = 10^9 nm

BONDING & IMAFs

Unit 2, 3a

Coulombic Attraction: $F \propto \frac{q_1 q_2}{r^2}$

q = charge (**more charge is more attraction**)

r = radius (**more distance is less attraction**)

LEWIS STRUCTURES

Count-----Connect-----Octet-----Octet-----Mult. Bonds
 (val e⁻s) (bonds) (outer) (central) (double or triple)

$$\text{Formal Charge} = \text{val e} - \# \text{ lone e} - \# \text{ bonds}$$

	domains	hybridization	shape	angle
AB ₂	2	sp	linear	180°
AB ₃	3	sp ²	trigonal planar	120°
AB ₄	4	sp ³	tetrahedral	109.5°
AB ₅	5	NA	trigonal bipyramidal	90° & 120°
AB ₆	6	NA	octahedral	90°

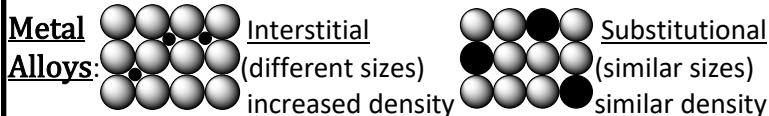
single	bond order = 1	σ (sigma)
double	bond order = 2	σ, π (sigma, pi)
triple	bond order = 3	σ, π, π (sigma, pi, pi)

IMAFs

- H-bonds** (if H bonded to very electronegative N,O,F)
 (e⁻ deficient H *attracts* N,O,F of another molecule)
- dipole-dipole int's (polar)**
 (stronger with greater Δ electronegativity)
- dispersion forces, LDFs (nonpolar)** (temporary dipoles)
 (stronger with more e⁻s, more polarizable)

ATTRACTIONS IN SOLIDS, LIQUIDS, & GASES

Type	Forces Between Particles	Properties
Molecular	Intermolecular Attractions (IMAFs) London dispersion forces (<i>nonpolar</i>) Dipole-dipole interactions (<i>polar</i>) $\delta^- \delta^+$ Hydrogen bonds (<i>H with N, O, F</i>)	Soft Low mp & bp Poor conductor
Covalent-Network	Covalent Bonds (network) C _(diamond) , SiO ₂ (quartz), WC ₂ (tungsten carbide), etc...	Very hard Very high mp Poor conductor
Ionic	Ionic Bonds crystal lattice of charged ions $\frac{q_1 q_2}{d}$	Hard and brittle High mp Conducts as (aq) or (l)
Metallic	Metallic Bonds + metal ions in delocalized "sea" of e⁻s	Soft to very hard Low to very high mp Malleable, Ductile, Conductor



Stronger Attractions cause...

- harder** and **higher mp** of solid (higher ΔH_{fusion})
- higher bp** of liquid (higher $\Delta H_{\text{vaporization}}$)
- higher viscosity** (resistance to flow)
- lower vapor pressure** (less vapor above a liquid)

MASS, COMPOSITION, STOICH. & SOLUTIONS

$$\text{mass \%} = \frac{\text{g part}}{\text{g total sample}} \times 100\%$$

Unit 1, 3b, 3c, 4c

$$\% \text{ yield} = \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

$$\% \text{ error} = \frac{|\text{experimental} - \text{theoretical}|}{\text{theoretical}} \times 100\%$$

$$\text{moles (n)} = \frac{\text{mass (g)}}{\text{molar mass (MM)}}$$

$$\frac{6.022 \times 10^{23}}{1 \text{ mole}}$$

Find EMPIRICAL & MOLECULAR FORMULA:

- 1) % to mass (g) (if %'s given, write as grams)
- 2) mass to mol (convert with molar mass)
- 3) ÷ by small (to get lowest ratio)
- 4) times 'til whole (if necessary, x by 2 or 3)

$$\frac{\text{molecular mass}}{\text{empirical mass}} = \text{multiple of empirical} \rightarrow \text{Molecular Formula}$$

STOICHIOMETRY

$$\text{g A} \times \frac{1 \text{ mol A}}{\text{g A}} \times \frac{\text{mol B}}{\text{mol A}} \times \frac{\text{B}}{\text{unit of B}} = \text{Whatever asked for.}$$

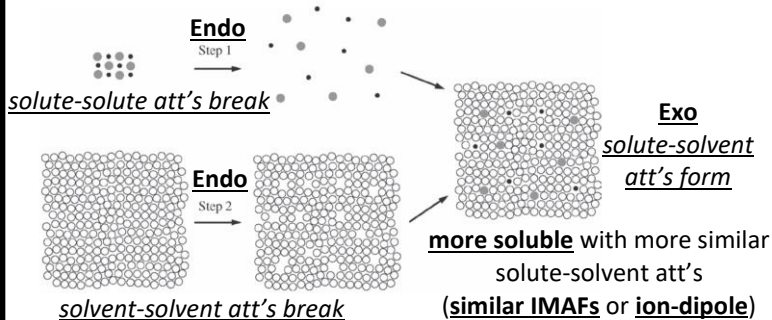
ELECTROLYTES: ionize or dissociate into charges (strong, weak, non) in solution conducting electricity

Always soluble ions: **SNAP** (Na^+ , NO_3^- , NH_4^+ , K^+)

Concentration [] in **Molarity**, $M = \frac{\text{moles solute}}{\text{L solution}}$

$$M_1V_1 = M_2V_2 \text{ (dilution)} \quad 1000 \text{ mL} = 1 \text{ L}$$

SOLUTION FORMATION



BEER-LAMBERT LAW (LAB)

concentration determined by light absorbed thru solution

$$A = \epsilon bc$$

A = absorbance

ϵ = molar absorptivity ($M^{-1}\text{cm}^{-1}$)

b = path length (cm)

c = concentration (M)

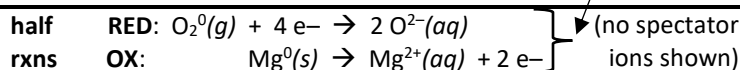
Greater A (absorbance), Higher c (concentration)

REACTIONS Net Ionic Equations (NIE's)

Unit 4a

Complete-----**Dissociate**-----**Cross**-----**Net**-----**Bal**
(molecular) (strongs & SNAP) (spectators) if REDOX: O HE BAL U

REDOX (OX#'s change) (elements have OX# 0)



- 1) **Synthesis** $2\text{Mg}^0 + \text{O}_2^0 \rightarrow 2\text{Mg}^0$
- 2) **Decomposition** $2\text{H}_2\text{O} \rightarrow 2\text{H}_2^0 + \text{O}_2^0$
- 3) **Single Replacement** (metal + acid) $\text{Zn}^0 + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2^0(g)$
Single Replacement (metal + metal ion) $2\text{Na}^0 + \text{Fe}^{2+} \rightarrow 2\text{Na}^+ + \text{Fe}^0$
- 4) **Combustion** $\text{CH}_4 + \text{O}_2^0 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

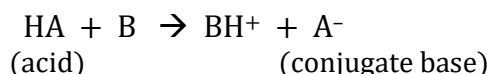
NOT REDOX (same ions w/ same charges, just switch partners)

- 5) **Double Rep. (Precipitation)** $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(s)$
Double Rep. (Acid-Base) $\text{HC}_2\text{H}_3\text{O}_2 + \text{OH}^- \rightarrow \text{C}_2\text{H}_3\text{O}_2^- + \text{H}_2\text{O}$
Double Rep. (acid + carbonate) $\text{MgCO}_3 + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2\text{O} + \text{CO}_2(g)$

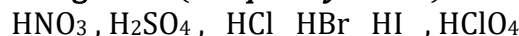
ACIDS & BASES

Unit 4c

Acid: donates proton (H^+)

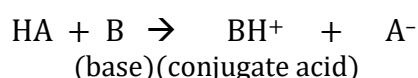


Strong Acids (**completely** ionize)



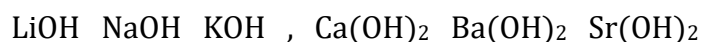
5A 15 N	6A 16 O	7A 17 F	2 He
15 P	16 S	17 Cl	18 Ar
33 As	34 Se	35 Br	36 Kr
51 Sb	52 Te	53 I	54 Xe
83 Bi	84 Po	85 At	86 Rn

Base: accepts proton (H^+)



Strong Bases (**completely** ionize)

hydroxides (OH^-) of Group 1 and CBS

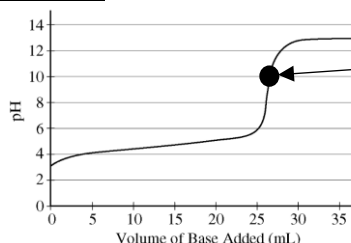


1 H	2A 2 He
3 Li	4 Be
11 Na	12 Mg
19 K	20 Ca
37 Rb	38 Sr
55 Cs	56 Ba

pH

$$\text{pH} = -\log[\text{H}^+] \quad [\text{H}^+] = 10^{-\text{pH}}$$

TITRATION



Equivalence Point:
equal stoichiometric
amounts of
analyte and titrant



Stoich: $\frac{\text{L T} \times \text{mol T}}{1 \text{ L T}} \times \frac{\text{X mol A}}{\text{Y mol T}} = \frac{\text{mol A}}{\text{g}} \div \text{L} = \frac{\text{M}}{\text{g}}$

GASES

Unit 3b

$$PV = nRT \quad (\text{Ideal Gas Law})$$

$$P = \text{pressure} \quad 1 \text{ atm} = 760 \text{ mmHg} = 760 \text{ torr}$$

$$V = \text{volume (L)} \quad 1 \text{ L} = 1000 \text{ mL}$$

$$n = \text{moles}$$

$$R = \text{gas constant} \quad 0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \text{ OR } 62.36 \frac{\text{L}\cdot\text{torr}}{\text{mol}\cdot\text{K}}$$

$$T = \text{temperature (K)} \quad ^\circ\text{C} + 273 = \text{K}$$

$$MM = \frac{mRT}{PV} \quad (\text{molar mass of a gas})$$

$$P_A = P_{\text{total}} \times X_A \quad \text{mole fraction, } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{\text{total}} = P_A + P_B + P_C + \dots$$

$$\text{STP} = 273.15 \text{ K and } 1.0 \text{ atm}$$

$$22.4 \text{ L}\cdot\text{mol}^{-1} \text{ @ STP} \quad (\text{volume of 1 mol of gas})$$

$$\text{Density (D)} = \frac{m}{V} \quad MM = \frac{DRT}{P}$$

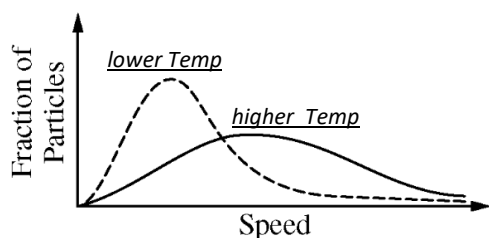
$$KE_{\text{molecule}} = \frac{1}{2}mv^2$$

m = mass (or molecular mass)

v = velocity

lower mass ($\downarrow m$), faster speed ($\uparrow v$)

higher Temp ($\uparrow KE$), faster speed ($\uparrow v$)



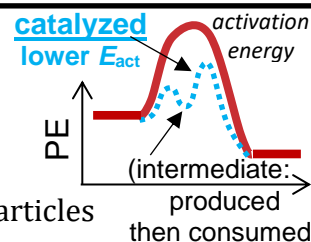
IDEAL vs NON-IDEAL

Most ideal with **weakest IMAFs** and at:

- **high Temp** b/c IMAFs are negligible (high KE)
- **low Pressure** b/c particle volume is negligible compared to great total volume

KINETICS

Unit 5



Rate of rxn depends on:

- 1) collision **frequency**
- 2) collision **energy** (E_{act})
- 3) proper **orientation** of particles

\uparrow exposed surface area = more frequent collisions

\uparrow concentration = more frequent collisions

\uparrow Temp = more frequent collisions & more KE

Rate = $k[A]^m[B]^n$ (general rate law)

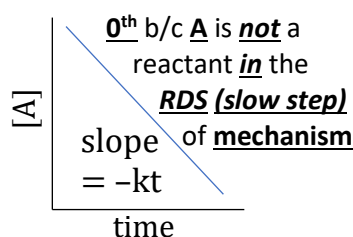
shows reactants in RDS (slow step) of mechanism

$[A]_t$ = concentration of A after some amount of time

$[A]_0$ = initial concentration of A

0th order: rate law: **Rate** = k

integrated rate law: $[A]_t - [A]_0 = -kt$



Rate is M/t so:

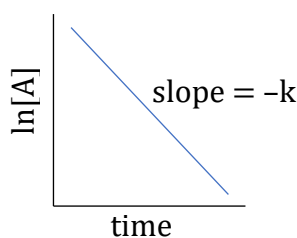
$$\text{Rate} = k$$

$$\frac{M}{t} = ?$$

units of k : $M \cdot t^{-1}$
 t is s OR min OR etc.

1st order: rate law: **Rate** = $k[A]^1$

integrated rate law: $\ln[A]_t - \ln[A]_0 = -kt$



Rate is M/t so:

$$\text{Rate} = k[A]^1$$

$$\frac{M}{t} = ? \cdot M$$

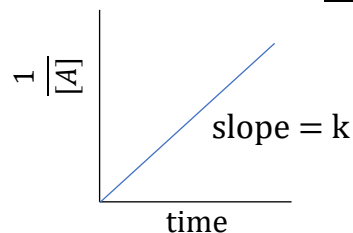
units of k : t^{-1}
 t is s OR min OR etc.

1st order has **constant half-life** ($t_{1/2}$)

$$t_{1/2} = \frac{0.693}{k}$$

2nd order: rate law: **Rate** = $k[A]^2$

integrated rate law: $\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$



Rate is M/t so:

$$\text{Rate} = k[A]^2$$

$$\frac{M}{t} = ? \cdot M^2$$

units of k : $M^{-1} \cdot t^{-1}$
 t is s OR min OR etc.

THERMODYNAMICS

Unit 6

$-\Delta H = \text{exothermic}$
(heat lost to surroundings so \uparrow Temp)
 $+\Delta H = \text{endothermic}$
(heat absorbed from surroundings so \downarrow Temp)

If rxn is reverse, ... then ΔH is opposite ($-\Delta H$).

If rxn is multiplied by 2, $\frac{1}{2}$, 3, etc....
...then ΔH is multiplied by that number, too.

If rxn 1 is added to rxn 2, ...
...then ΔH_1 is also added to ΔH_2

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \text{BE}(\text{reactants}) - \sum \text{BE}(\text{products})$$

(bonds broken) - (bonds formed)

CALORIMETRY (LAB)

$$q = mc\Delta T$$

q = heat energy (J)

m = mass (g)

c = specific heat capacity ($\frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$) or ($\frac{\text{J}}{\text{g}\cdot\text{K}}$)

ΔT = change in temperature ($^\circ\text{C}$) or (K)

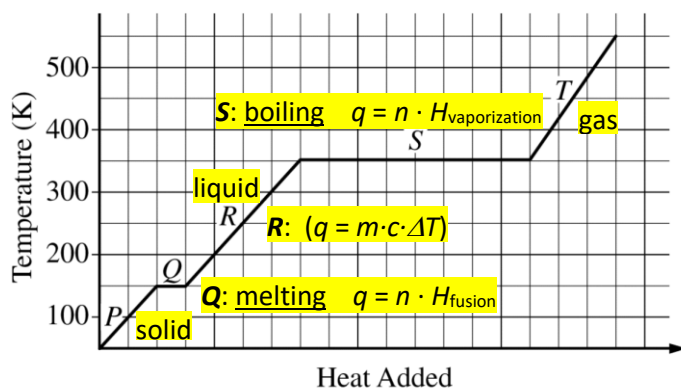
$$\Delta H_{\text{system}} = -q_{\text{surroundings}}$$

convert J to kJ and \div by moles to get "molar heat of rxn"
(ΔH_{rxn} in kJ/mol)

c = specific heat capacity ($\frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$) or ($\frac{\text{J}}{\text{g}\cdot\text{K}}$)

means the amount of heat energy lost *OR* gained
to change 1 g of matter by 1°C .

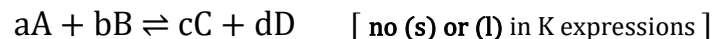
HEATING CURVES



In Sections Q and S, added heat does not increase KE (Temp), but increases PE by overcoming attractions and separating particles to change phase.

EQUILIBRIUM

Unit 7



$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \quad (\text{conc's in } M) \quad (aq) \text{ OR } (g)$$

$$K_p = \frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b} \quad (P \text{ in atm}) \quad (g) \text{ ONLY}$$

$K > 1$; more products than reactants @ equilibrium

$K < 1$; more reactants than products @ equilibrium

If rxn is reverse, ... then K is inverse ($1/K$ OR K^{-1})

If rxn is multiplied by 2, $\frac{1}{2}$, 3, etc....

...then K is raised to that power: K^2 , $K^{1/2}$, K^3 , etc.

If rxn 1 is added to rxn 2, ...

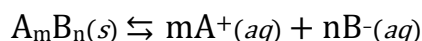
...then K_1 is multiplied to K_2

Q (reaction quotient)

$Q = K$; at equilibrium

$Q > K$; too much product, shift left form reactant

$Q < K$; too much reactant, shift right form product



$$K_{sp} = [A^+]^m[B^-]^n \quad (\text{solubility product constant})$$

$Q = K$; saturated

$Q > K$; saturated, shift left to precipitate solid

$Q < K$; unsaturated, shift right dissolve into ions

Common Ion Effect: *shift left* (less soluble)

Use **RICE tables** to track what changes during rxn:

R eaction (shows mole ratios as coefficients)

I nitial (write units! mol OR M OR atm)

C hange

E quilibrium (write units! mol OR M OR atm)

Le Châtelier's Principle

System at equilibrium disturbed by change (affecting collisions) will shift (\leftarrow or \rightarrow) to counteract the change.

- **Add** R or P: shift away faster (*consume*)
- **Remove** R or P: shift toward faster (*replace*)
- **Volume**: $\downarrow V$ shifts to fewer mol of gas ($\downarrow n_{\text{gas}}$)
(P_{total}) $\uparrow V$ shifts to more mol of gas ($\uparrow n_{\text{gas}}$)
- **Temp.** (changes K) ($H + R \leftrightarrow P$) ($R \leftrightarrow P + H$)
 $\uparrow T$ shifts in endo dir. to use up heat
 $\downarrow T$ shifts in exo dir. to make more heat
- **Catalyst**: no shift